Lands for Tomorrow
June 28, 2011
Melanie Seigler
Director of Information Systems
Virginia Department of Forestry

Introduction to GIS and GPS

What We Will Cover Today

- Definition and high level look at Geographic Information Systems (GIS) data and potential issues
- Definition and high level look at Global Positioning Systems (GPS) data and potential issues.

Why Focus on the Data?

- To provide understanding of spatial data basics
- To raise awareness of common issues with collecting and using spatial data

GIS - Geographic Information Systems

- Definition

"An organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of ***geographically referenced data****." (Understanding GIS, 1997)

* Commonly referred to as "spatial" data

What Makes Data "Spatial" ?

- Latitude/Longitude (or other coordinate systems)
- Place names
- Address & zip code
- Distance and bearing
- Real world objects

Why is Spatial Data Unique?

- Information referenced by its location
- Make connections between activities based on spatial proximity
- Create relationships between otherwise unrelatable data

"Everything is related to everything else, but near things are more related than distant things" - Waldo Tobler, 1970

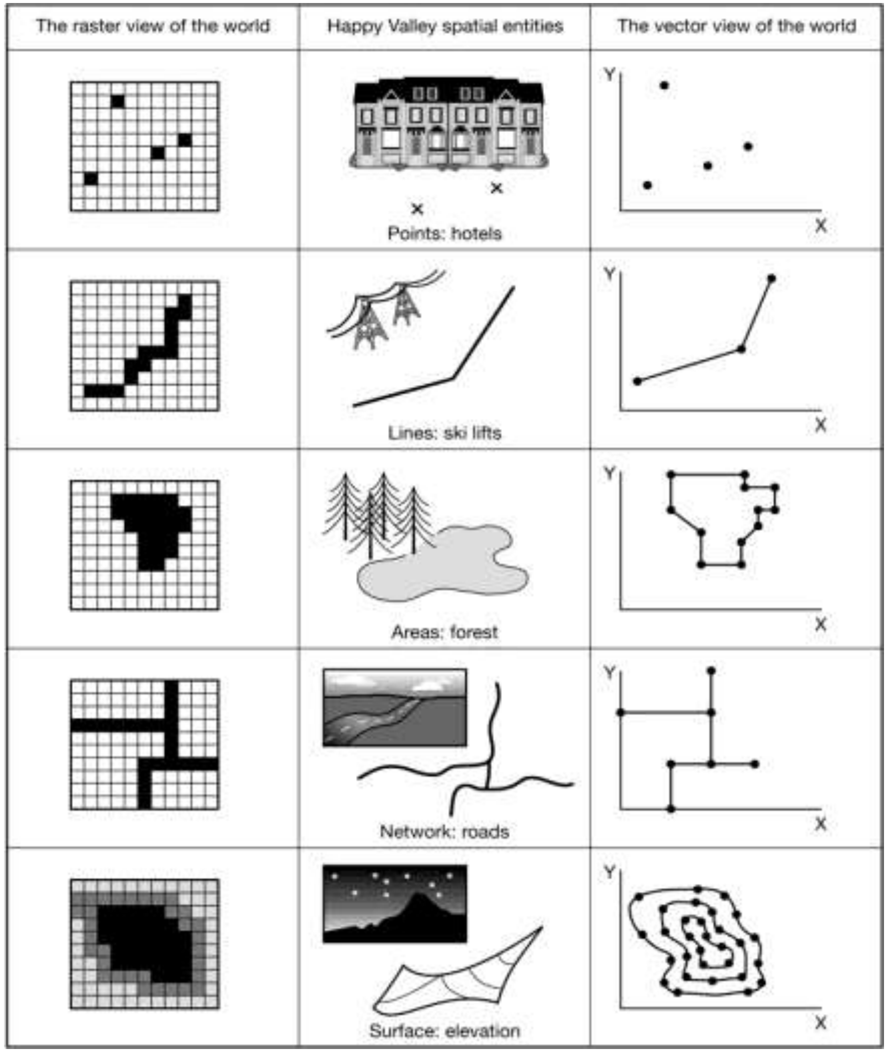
Why Use Spatial Data?

Many of the questions we have a geographic component

- Land management
- Emergency response
- Property lines, easements, right of way
- Proximity of “our” land to other land/facilities (hunting, pollution, federal, state, protected.)

Spatial Data Representations:
Raster & Vector

- Raster
  - Break the area being represented into "pixels" (picture elements)
  - Assign each pixel a value that may represent continuous or discrete values
- Vector
  - Uses points and line to represent features.
  - Polygons (points and lines linked together



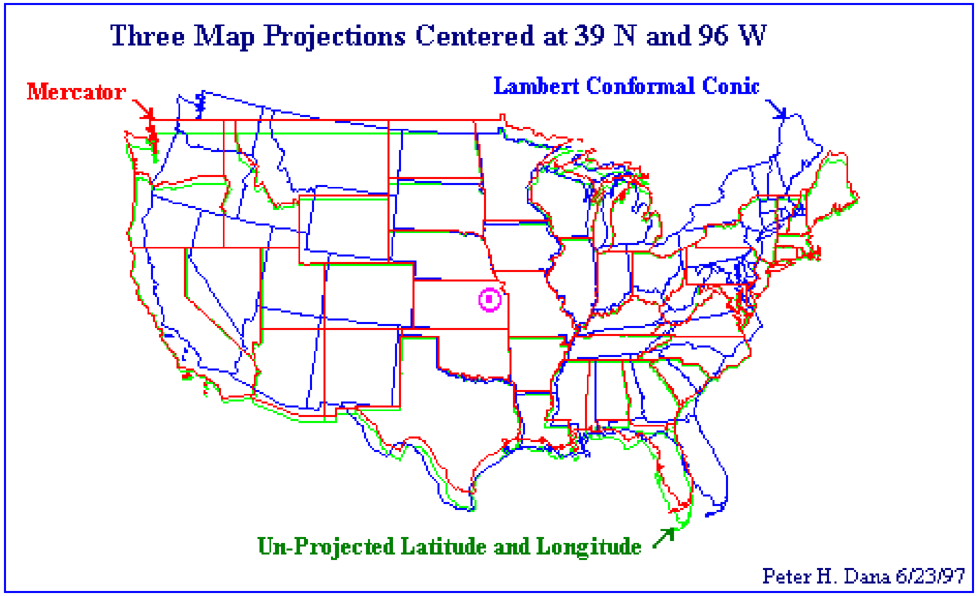
Common Issues to be Aware of When Using Spatial Data

- (Map) Projection
- (Map)Scale
- Error
- Accuracy
- Precision
- Lineage
- Metadata

Projection

Flattening the 3-D globe into a 2-D map, something is always distorted

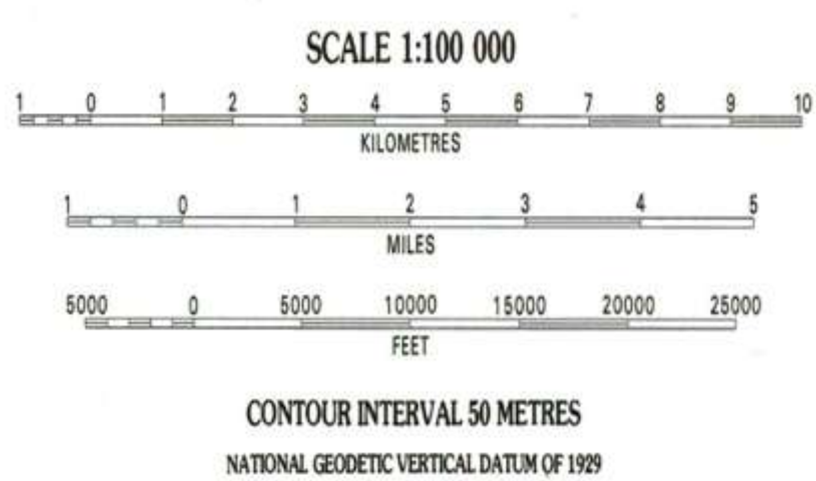
- **S**hape
- **A**rea
- **D**istance, or
- **D**irection



Always know the map projection in which your data was created so to determine if it is the best fit for your analysis

Map Scale

- The ratio of a distance on the map to the corresponding distance on the ground in the same unit of measure
- Scale can also be expressed with scale bar, with words, or as a fraction
- CAUTION! You will sometimes see **equivalence** scales
  1″ = 1200′



One centimeter to one kilometer

1″ = 1200′ **IS NOT** 1:1200

1:14,400

Accuracy

- **Accuracy** is the degree to which information on a map or in a digital database matches true or accepted values.
- Accuracy is an issue pertaining to the **quality of data and the number of errors**
- Consider **horizontal and vertical** accuracy with respect to geographic position, as well as **attribute, conceptual, and logical** accuracy.
  - The level of accuracy required for particular applications varies greatly
  - Highly accurate data can be very difficult and costly to produce and compile

Precision

- **Precision** refers to the **level of measurement and exactness of description** in a GIS database.
- Precise locational data may measure position to a fraction of a unit.
- Precise attribute information may specify the characteristics of features in great detail. “Blonde” – “Strawberry Blonde”
- Precise data--no matter how carefully measured--may be inaccurate.
- The level of precision required for particular applications varies greatly.
- Highly precise data can be very difficult and costly to collect.
- **High precision does not indicate high accuracy nor does high accuracy imply high precision. But high accuracy and high precision are both expensive.**

Error

- Error encompasses both imprecision and inaccuracies of data
- Error can disrupt your GIS analyses, so keep it to a minimum through careful project planning
- Error is found in positional accuracy & precision
- REPEAT - To manage error, careful planning is needed!

Positional Accuracy and Precision

- Accuracy and precision are a function of the scale at which a map (paper or digital) was created. The mapping standards employed by the United States Geological Survey specify that:
  - "requirements for meeting horizontal accuracy as 90 per cent of all measurable points must be within 1/30th of an inch for maps at a scale of 1:20,000 or larger, and 1/50th of an inch for maps at scales smaller than 1:20,000."
- This means that when we see a point on a map we have its "probable" location within a certain area. The same applies to lines.

Positional Accuracy and Precision

- Beware of the dangers of false accuracy and false precision, that is reading locational information from map to levels of accuracy and precision beyond which they were created.
- Less accurate data isn't "wrong" – just collected at a different map scale, and used for different analysis
  - If you want to accurately locate your house on a map, you can't use a map of the United States
  - If you want to do a multi state analysis, you don't need neighborhood data

[Accuracy Standards for Various Scale Maps]

- 1:1,200 ± 3.33 feet
- 1:2,400 ± 6.67 feet
- 1:4,800 ± 13.33 feet
- 1:10,000 ± 27.78 feet
- 1:12,000 ± 33.33 feet
- 1:24,000 ± 40.00 feet
- 1:63,360 ± 105.60 feet
- 1:100,000 ± 166.67 feet

More on Error

- Attribute accuracy and precision - Census
  - An accurate description would include the correct information for a person
  - A precise description might include gender, age, income, occupation, level of education, etc. An imprecise description might include just income, or just gender

Lineage

- What is the age of the data?
- Where did it come from?
- In what medium was it originally produced?
- What is the areal coverage of the data?
- To what map scale was the data digitized?
- What projection, coordinate system, and datum were used in maps?
- What was the density of observations used for its compilation?
- How accurate are positional and attribute features?
- Does the data seem logical and consistent?
- Do cartographic representations look "clean?"
- Is the data relevant to the project at hand?
- In what format is the data kept?
- How was the data quality checked?
- Why was the data compiled?
- What is the reliability of the provider?

Metadata

- Data about the Data
  - Projection, Scale Accuracy, Precision, Error, and more!
- Provides a standard way of organizing the data's information so users can quickly assess whether it meets their needs

Metadata Standards

- Federal Geographic Data Committee (FGDC) Content Standard for Digital Geospatial Metadata (CSDGM)
  - http://www.fgdc.gov/metadata/geospatial-metadata-standards#csdgm
- Virginia Spatial Metadata Lite standard
  - http://gisdata.virginia.gov/Portal/ptk?command=openchannel&channel=21

GPS – The Global Positioning System

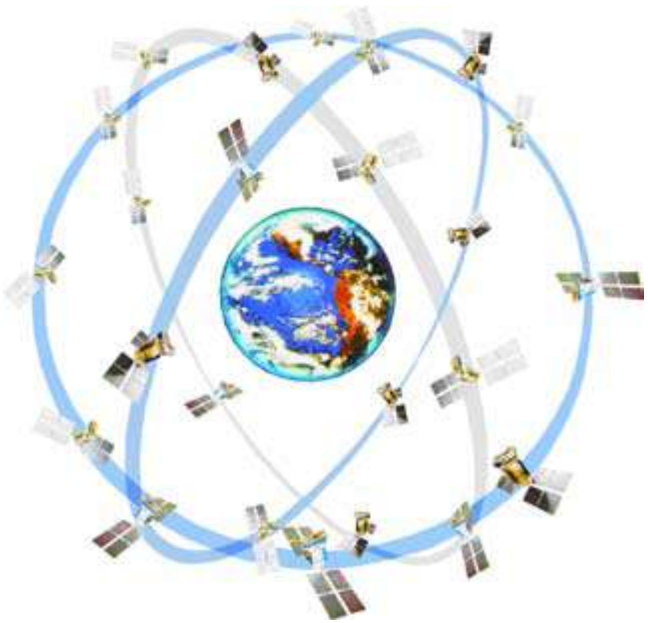
- The original GPS is funded by and controlled by the U.S. Department of Defense (DOD).
- New satellite navigation systems are being developed by Russia (GLONASS), the EU (Galileo/EGNOS), China (Compass/BeiDou), Japan (MSAS/QZSS) and India (IRNSS/GAGAN)
- GPS provides specially coded satellite signals that can be processed in a **GPS receiver**, enabling the receiver to compute position, velocity and time.
- **Four** GPS satellite signals are used to compute positions in three dimensions and the time offset in the receiver clock

Three Pieces of the GPS

- Space Segment – The satellites
- Control Segment – Tracking stations around the world
- User Segment – GPS receivers and user community

Space Segment

- 24 satellites (sometimes more)
- Orbit the earth in 12 hours.
- Repeat the same track and configuration over any point about every 24 hours (4 min earlier each day)
- There are six orbital planes with four satellites in each, equally spaced 60 degrees apart and inclined at about fifty-five degrees to the equatorial plane.
- This positioning provides between five and eight satellites visible from any point on the earth

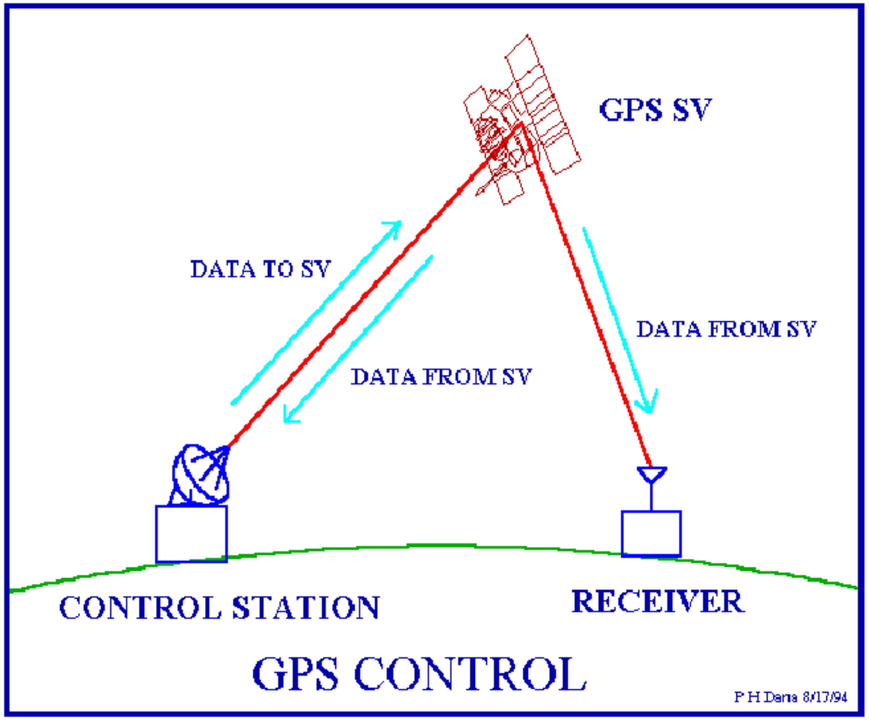


The Control Segment

- The Master Control facility uploads the ephemeris (table of positions of astronomical objects) and clock data to satellite

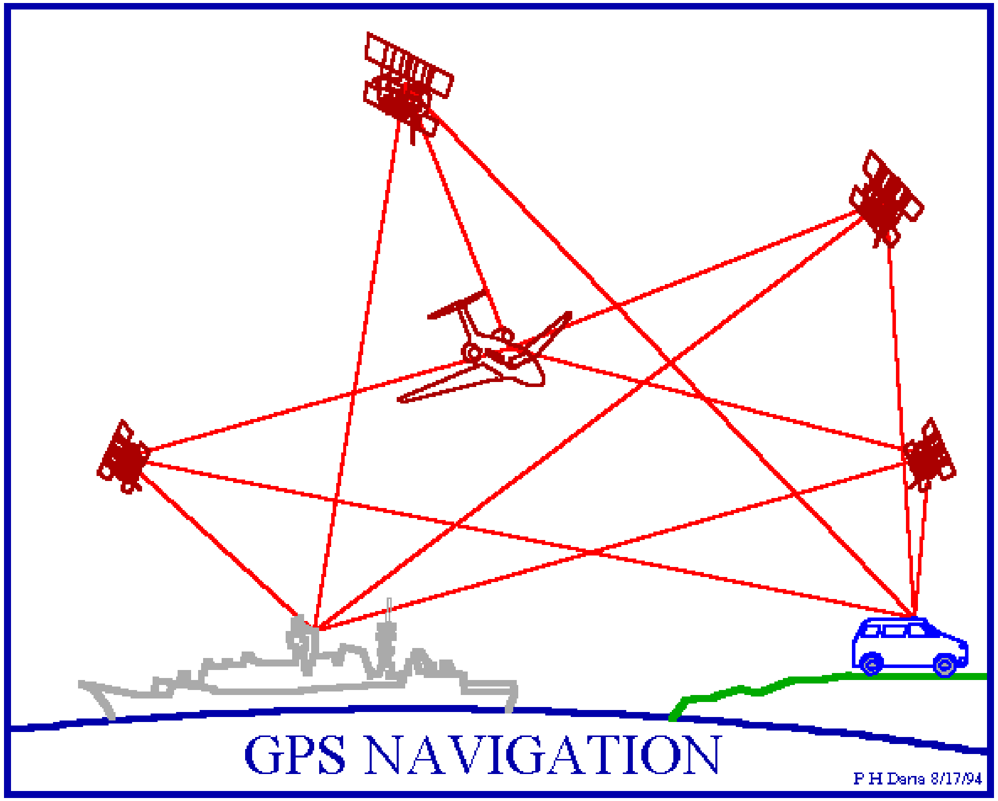
- All control facilities measure signals from satellites

- Satellites send subsets of orbital ephemeris to GPS receivers over radio signals



User Segment

- GPS receivers convert signals into position, velocity and time estimates
- Four satellites are required to compute the four dimensions – X, Y, Z and Time



Positioning Services

- Delivering different levels of Accuracy and Precision
  - Standard Positioning Services (SPS)
  - Precision Positioning Service (PPS - Military)
  - Wide Area Augmentation Services (WAAS)

GPS Receivers

- Delivering different levels of Accuracy and Precision
  - Survey, Personal use, Dashboard Navigation

GPS Error Sources

- Ionosphere and troposphere disturbances causing the signal to slow down
- Signal reflection, off tall buildings, rocks, etc
- Ephemeris errors – errors in the satellite's reported position against its actual position
- Clock errors – the clock in the GPS receiver is not as accurate as the satellite clock
- Visibility of satellites – blocked by buildings, rocks, dense foliage or electronic interference
- Satellite shading – satellites are not at wide angles from each other creating poor geometry

http://www.roseindia.net/technology/gps/sources-of-GPSe-error.shtml

GPS Techniques and Project Costs

- Receiver costs vary depending on capabilities
  - Under $200 – less accurate, but close enough for some projects
  - Over $5000 for engineering-grade, highly accurate
- Other Costs – how many receivers needed, software to post-process, training or trained personnel
- Project tasks can often be categorized by required accuracies which will determine equipment cost
  - Low-cost, single-receiver SPS (100 meter accuracy)
  - Medium-cost, differential SPS code Positioning (1-10 meter accuracy)
  - High-cost, single-receiver PPS projects (20 meter accuracy)
  - High-cost, differential carrier phase surveys (1 mm to 1 cm accuracy)

Final Thoughts

- Before use of GIS or GPS data – check the metadata and documentation to make sure it is what you need – but not too much
- Before you begin a project to collect GIS data – through GPS or other means – develop a plan
  - What is the accuracy I need?
  - What will it cost to gather this data at this accuracy? (equipment, staff, hardware, cost/benefit)
  - Will this be an on-going data collection, or a one-time data collection?
    - This an help determine what type of data collection format you want to build.

Resources for More information on the Web

- The Geographer's Craft
http://www.colorado.edu/geography/gcraft/contents.html
- University of Virginia Scholar's Lab – Introduction to GIS
http://www.lib.virginia.edu/scholarslab/resources/class/mlbs/introToGIS.pdf
- Rose India - GPS
http://www.roseindia.net/technology/gps/sources-of-GPSe-error.shtml
- GPS.Gov

http://www.gps.gov/